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Livingston Reservoir, Polk, San Jacinto, Trinity, and Walker Counties, Texas

National Eutrophication Survey, Corvallis, Oreg

Prepared for

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

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REPORT
ON
LIVINGSTON RESERVOIR
POLK, SAN JACINTO, TRINITY, AND WALKER COUNTIES
TEXAS
EPA REGION VI
WORKING PAPER No. 651

WITH THE COOPERATION OF THE
TEXAS WATER QUALITY BOARD
AND THE
TEXAS NATIONAL GUARD
FEBRUARY, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

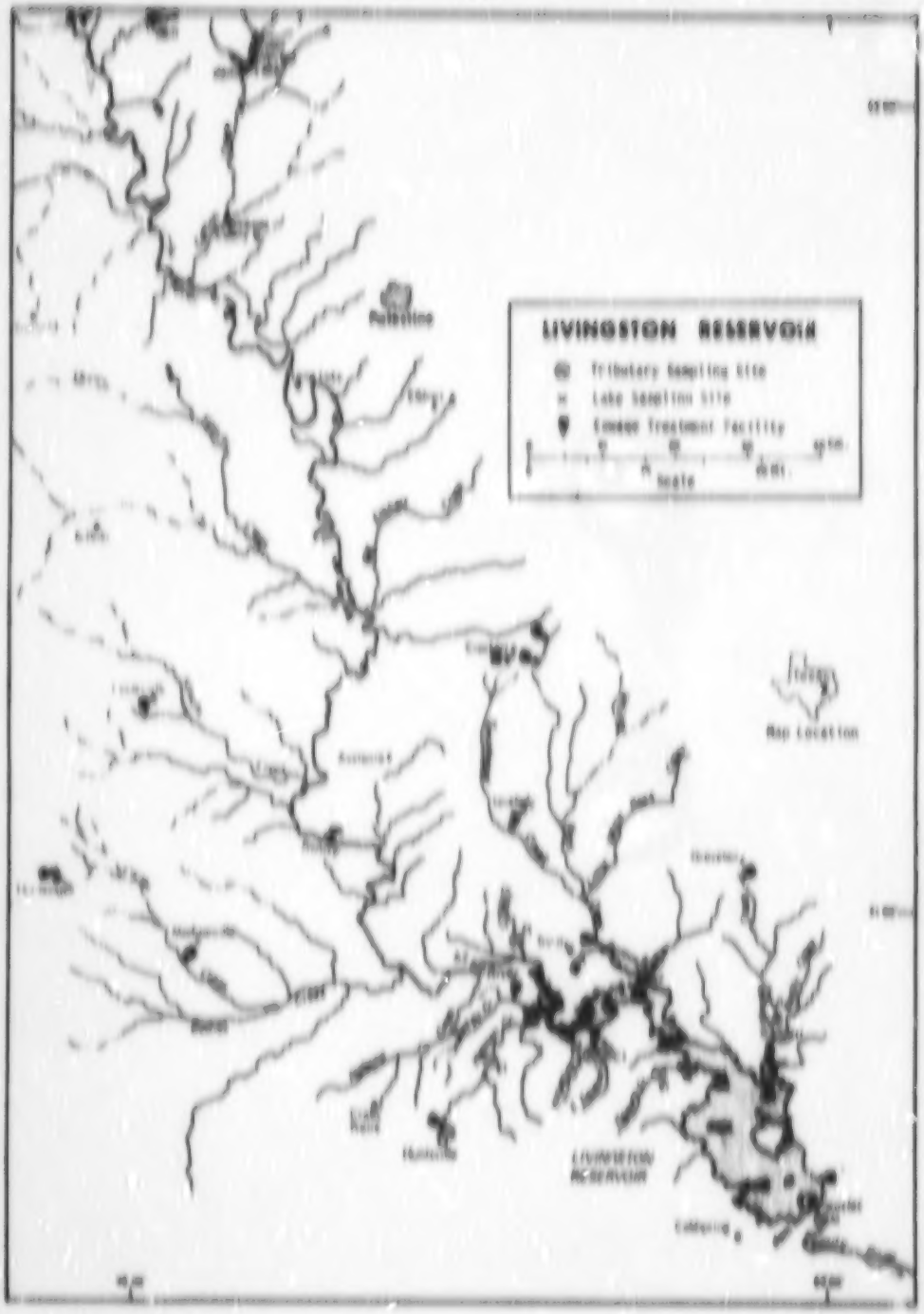
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Pussum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
E. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass


LIVINGSTON RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Scale
Map Location
LIVINGSTON RESERVOIR

LIVINGSTON RESERVOIR
STORET NO. 4820

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Livingston Reservoir is eutrophic; i.e., well supplied with nutrients and quite productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the reservoir. In this regard, the Texas Water Quality Board has indicated that there is little or no known impairment of the designated beneficial uses of this water body.

Livingston Reservoir ranked last in overall trophic quality when the 33 Texas reservoirs sampled in 1974 were compared using a combination of six water quality parameters*. Thirty-seven of the reservoirs had less median total phosphorus, median dissolved orthophosphorus, and median inorganic nitrogen; 28 had less mean chlorophyll a, and 23 had greater mean Secchi disc transparency. Marked depression or depletion of dissolved oxygen with depth occurred at all stations in May and August.

Survey limnologists noted emergent vegetation in March at stations 6 and 8; in May at stations 2, 5, 7, and 8; and in August at station 2. In another study on this water body, macrophyte growths sufficient to impede boat traffic in several areas were reported (Anonymous, 1974 [?]).

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* See Appendix A.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Livingston Reservoir was limited by nitrogen at the times samples were collected (03/16/74 and 11/17/74). The reservoir data indicate nitrogen limitation at all sampling stations and times. Other investigators also have indicated that the reservoir is nutrient-enriched and limited by nitrogen (Huang, Mase, and Fruh, 1973).

C. Nutrient Controllability:

1. Point sources--During the sampling year, listed point sources contributed 2.0% of the total phosphorus load to Livingston Reservoir. The wastewater treatment plant at Huntsville was the largest contributor of 14 municipal facilities and accounted for 1.1% of the total.

The present phosphorus loading of 0.43 g/m^2/year is eight times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 17). Even complete removal of phosphorus at the listed point sources would not significantly decrease the present loading, although phosphorus removal at Huntsville could result in some improvement in Harmon Creek embayment; a major portion of the load in this tributary appears to be from the wastewater treatment plant as indicated by high nutrient concentrations at station E-1 (see Appendix E). However, overall improvement in trophic quality is dependent upon the controllability of phosphorus from upstream sources which impact the Trinity River (see discussion below).

8. Non-point sources--During the sampling year, non-point sources contributed 98.0% of the total phosphorus input to Livingston Reservoir. The Trinity River contributed 97.3% of this total, four other gaged tributaries contributed less than 0.1%, and the ungaged minor tributaries and immediate drainage contributed an estimated 0.4%.

The non-point phosphorus export rate of the Trinity River (52 kg/km^2/year) is over 15 times the mean of the exports of the other gaged tributaries of Livingston Reservoir (see page 16) and is indicative of additional point sources upstream; e.g., the Dallas metropolitan area. Further investigation is needed to determine the controllability of phosphorus from all point sources as well as from land-use practices in the Trinity River drainage basin.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 334.88 kilometers².
2. Mean depth: 6.5 meters.
3. Maximum depth: >21.3 meters.
4. Volume: 2,158.608 x 10^6 m^3.
5. Mean hydraulic retention time: 130 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Trinity River	39,943.0	173.910
Palmetto Creek	52.3	0.188
E. Carolina Creek	31.6	0.110
Hammon Creek	114.0	0.500
Rocky Creek	100.6	0.460
Minor tributaries & immediate drainage -	2,374.0	16.380
Totals	42,615.7	191.576

2. Outlet -

Trinity River	42,950.0**	191.550

C. Precipitation***:

1. Year of sampling: 144.8 centimeters.
2. Mean annual: 114.3 centimeters.

† Table of Metric Conversions--Appendix B.
†† Anonymous, 1974(?).
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Livingston Reservoir was sampled four times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at eight stations on the reservoir (see map, page vi). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the March and November visits, 18.9-liter depth-integrated samples were composited from stations 1, 2, 3, and 4 and 5, 6, 7, and 8 for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 21.3 meters at station 1, 19.5 meters at station 2, 15.8 meters at station 3, 7.6 meters at station 4, 17.1 meters at station 5, 15.5 meters at station 6, 11.9 meters at station 7, and 12.5 meters at station 8.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not properly preserved and were not analyzed).

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LIVINGSTON LAKE
STREET CODE 408

PARAMETER	1ST SAMPLING (JAN-FEB)			2ND SAMPLING (MAR-APR)			3RD SAMPLING (MAY-JUN)		
	# SITES			# SITES			# SITES		
	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	14.3 - 19.7	16.3	16.7	23.3 - 29.6	26.7	26.3	26.8 - 31.7	29.1	29.0
[illegible]	2.9 - 9.0	7.2	7.9	0.4 - 12.6	4.4	4.2	0.0 - 10.4	3.2	1.0
[illegible]	211. - 447.	299.	295.	274. - 455.	368.	405.	455. - 726.	495.	495.
[illegible]	6.8 - 8.3	7.6	7.6	7.3 - 9.5	8.2	7.9	7.3 - 9.2	8.0	9.0
[illegible]	55. - 112.	81.	77.	81. - 111.	93.	91.	----	----	----
[illegible]	0.159 - 0.368	0.258	0.259	0.097 - 0.767	0.386	0.335	----	----	----
[illegible]	0.086 - 0.478	0.282	0.258	0.028 - 0.225	0.103	0.097	----	----	----
[illegible]	0.378 - 1.020	0.774	0.660	0.042 - 1.250	0.484	0.278	----	----	----
[illegible]	0.040 - 0.268	0.092	0.050	0.041 - 0.299	0.093	0.078	----	----	----
[illegible]	0.238 - 1.180	0.684	0.680	0.308 - 1.480	0.795	0.788	----	----	----
[illegible]	0.418 - 1.328	0.671	0.735	0.188 - 1.259	0.481	0.1---	----	----	----
[illegible]	1.126 - 2.098	1.399	1.435	0.560 - 2.688	1.389	1.126	----	----	----
[illegible]	7.0 - 46.3	25.4	25.0	3.3 - 43.4	20.8	8.2	24.7 - 28.0	26.1	26.6
[illegible]	0.5 - 1.0	0.7	0.6	0.6 - 1.5	1.0	1.0	0.8 - 1.6	1.2	1.0

[illegible] SUMMARY OF PHYSICAL AND CHEMICAL [illegible] FOR LONGMONT LAKE
SEPTEMBER 1985

[illegible] SAMPLING [illegible]

PARAMETER	# SITES RANGE	MEAN	MEDIAN
TEMP (C)	24.2 - 25.8	25.0	25.7
DISS OXY (MG/L)	4.8 - 7.6	6.2	5.8
CONDTVY (MICROMHO)	294. - 334.	263.	296.
PH (STAND UNITS)	7.8 - 7.9	7.4	7.4
TOT ALK (MG/L)	52. - 96.	74.	82.
TOT P (MG/L)	0.111 - 0.760	0.274	0.234
DISS P (MG/L)	0.075 - 0.397	0.173	0.128
NO2+NO3 (MG/L)	0.259 - 1.350	0.481	0.356
AMMONIA (MG/L)	0.022 - 0.276	0.098	0.035
KJEL N (MG/L)	0.480 - 1.288	0.783	0.788
ORG N (MG/L)	0.258 - 1.408	0.538	0.340
TOTAL N (MG/L)	0.738 - 2.692	1.284	1.855
CHLOPHYL A (UG/L)	2.0 - 15.0	10.3	12.5
SECCHI (METERS)	0.2 - 1.4	0.4	0.5

B

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/18/74	1. Cyclotella sp.	3,017
	2. Melosira sp.	1,836
	3. Stephanodiscus sp.	1,236
	4. Chroomonas sp.	763
	5. Synedra sp.	473
	Other genera	363
	Total	9,488
05/24/74	1. Centric diatoms	9,691
	2. Merismopedia sp.	1,060
	3. Carteria sp.	916
	4. Chroomonas sp.	687
	5. Melosira sp.	686
	Other genera	2,441
	Total	15,491
08/19/74	1. Dactylococcopsis sp.	7,832
	2. Cyclotella sp.	6,433
	3. Merismopedia sp.	6,162
	4. Oscillatoria sp.	5,161
	5. Raphidiopsis sp.	3,069
	Other genera	2,752
	Total	32,599
11/06-07/74	1. Stephanodiscus sp.	021
	2. Melosira sp.	137
	3. Cryptomonas sp.	137
	4. Oscillatoria sp.	82
	5. Dactylococcopsis sp.	82
	Other genera	138
	Total	1,097

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2. Chlorophyll a

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/18/74	1	24.2
	2	46.3
	3	27.6
	4	19.0
	5	7.7
	6	13.8
	7	8.0
	8	12.1
05/24/74	1	5.0
	2	5.2
	3	6.7
	4	2.3
	5	5.7
	6	42.9
	7	6.9
	8	10.4
08/19/74	1	19.7
	2	20.3
	3	28.0
	4	23.6
	5	21.3
	6	26.1
	7	25.4
	8	26.1
11/06-07/74	1	12.9
	2	15.8
	3	14.0
	4	12.8
	5	7.1
	6	8.8
	7	14.4
	8	3.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. March sample -

(1). Stations 1, 2, 3, and 4.

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.126	0.780	15.4
0.050 P	0.176	0.780	17.1
0.050 P + 1.0 N	0.176	1.780	31.1
1.0 N	0.126	1.780	34.7

(2). Stations 5, 6, 7, and 8.

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.295	1.014	23.0
0.050 P	0.345	1.014	23.6
0.050 P + 1.0 N	0.345	2.014	41.5
1.0 N	0.295	2.014	37.3

b. November sample -

(1). Stations 1, 2, 3, and 4.

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.096	0.273	1.2
0.050 P	0.146	0.273	1.5
0.050 P + 1.0 N	0.146	1.273	5.5
1.0 N	0.096	1.273	3.2

(2). Stations 5, 6, 7, and 8.

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.246	0.690	23.0
0.050 P	0.296	0.690	24.0
0.050 P + 1.0 N	0.296	1.690	55.0
1.0 N	0.246	1.690	53.9

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3. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Livingston Reservoir was moderately high to very high at the times the samples were collected. Also, in all assays the lack of response with the addition of phosphorus until nitrogen was added, indicates that the reservoir was limited by nitrogen at those times. Note that the addition of only nitrogen resulted in yields which were significantly greater than those of the controls.

The reservoir data also indicate nitrogen limitation; i.e., the mean inorganic nitrogen/orthophosphorus ratios ranged from 13/1 at station 1 in March to 2/1 at station 8 in November, and nitrogen limitation would be expected.

Nitrogen limitation, as indicated by the algal assay or by in-lake nitrogen to phosphorus ratios, does not necessarily mean that the trophic condition of the reservoir can be improved by controlling nitrogen inputs. In many cases, the apparent condition of nitrogen-limitation results from excessive phosphorus input from point sources and is often accompanied by a corresponding increase in primary production. In such cases, the reversal of the enriched condition depends upon phosphorus control, not nitrogen control.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the month of April when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any. However, the nutrient loads estimated for the Huntsville wastewater treatment plant exceeded the loads measured in Harmon Creek at station E-1, and the background loads for this tributary and the unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/yr$, at stations B-1, C-1, and H-1 and multiplying the means by E-1 and ZZ areas in km^2.

The operators of the Galloways Marina, Madisonville, Memorial Point, Normangee, Texas Department of Corrections, and Trinity wastewater treatment plants provided monthly effluent samples and corresponding flow data.

* See Working Paper No. 175.

The operators of eight other listed wastewater facilities did not participate; nutrient loads from these sources were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Centerville**	600	stab. pond	227.1	Little Beaver Creek
Crockett**				
Plant #1	5,800	tr. filter, act. sludge	2,195.3	Gail Creek
Plant #2	1,200	act. sludge	454.2	Tantaboque Creek
Galloways Marina	200 (campground)	act. sludge	3.9	White Rock Creek
Groveton**	700	Imhoff tank	265.0	Kickapoo Creek
Huntsville	20,000	tr. filter	7,570.0	Town Branch
Kallita Point	20	tertiary	7.6	Lake Livingston
Lovelady	388	ext. aer.	146.9	Tantaboque Creek
Madisonville	3,050	act. sludge	954.9	Caney Creek
Memorial Point	300	act. sludge	226.1	Lake Livingston
Normangee	670	stab. pond	110.8	Hollis Creek
TX Dept. of Corrections	2,00	Imhoff tank	763.5	Turkey Creek
Trinity	3,600	act. sludge	678.6	Lake Livingston

2. Industrial - Unknown

* Treatment plant questionnaires.
** Anonymous, 1971.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Trinity River	2,091,430	97.3
Palmetto Creek	200	<0.1
E. Carolina Creek	90	<0.1
Harmon Creek	380	<0.1
Rocky Creek	405	<0.1
b. Minor tributaries & immediate drainage (non-point load) -	7,935	0.4
c. Known municipal STP's -		
Centerville	680	<0.1
Crockett	7,940	0.4
Galloways Marina	10	<0.1
Groveton	795	<0.1
Huntsville	22,680	1.1
Kalita Point	25	<0.1
Lovelady	440	<0.1
Madisonville	6,300	0.3
Memorial Point	70	<0.1
Normangee	110	<0.1
TX Dept. of Corrections	1,700	0.1
Trinity	1,490	0.1
d. Septic tanks* -	30	<0.1
e. Industrial - Unknown	?	-
f. Direct precipitation** -	5,850	0.3
Total	2,148,560	100.0

2. Outputs -

Lake outlet - Trinity River 923,050

3. Net annual P accumulation - 1,225,510 kg.

* Estimate based on 104 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Trinity River	11,648,965	94.1
Palmetto Creek	4,695	<0.1
E. Carolina Creek	2,985	<0.1
Harmon Creek	10,220	0.1
Rocky Creek	11,450	0.1
b. Minor tributaries & immediate drainage (non-point load) -	212,870	1.7
c. Known municipal STP's -		
Centerville	2,040	<0.1
Crockett	83,805	0.7
Galloways Marina	80	<0.1
Groveton	2,380	<0.1
Huntsville	66,020	0.6
Kalita Point	70	<0.1
Lovelady	1,320	<0.1
Madisonville	11,285	0.1
Memorial Point	215	<0.1
Normangee	325	<0.1
TX Dept. of Corrections	3,930	<0.1
Trinity	4,990	<0.1
d. Septic tanks* -	1,110	<0.1
e. Industrial - Unknown	?	-
f. Direct precipitation** -	360,890	2.9
Total	12,371,645	100.0

2. Outputs -

Lake outlet - Trinity River 7,703,650

3. Net annual N accumulation - 4,667,995 kg.

* Estimate based on 104 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Trinity River	59	292
Palmetto Creek	4	90
E. Carolina Creek	3	94
Rocky Creek	3	86

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
W. Carolina Creek	0.067	0.911
Chalk Creek	0.026	0.715
Kickapoo Creek	0.094	0.896

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	6.43	3.67	37.0	14.0

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Livingston Reservoir:

"Dangerous" (eutrophic loading)	0.80
"Permissible" (oligotrophic loading)	0.40

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. OWP-1, vol 6, Wash., DC.

Anonymous, 1974(?). Intensive surface water monitoring survey for segment 0803 (Lake Livingston). Rept. No. IMS 9. TX Water Qual. Bd., Austin.

Huang, Vikki H., J. Rusty Mase, and E. Gus Fruh, 1973. Nutrient studies in Texas impoundments. Jour. Water Poll. Contr. Fed., vol. 45, no. 1 (Jan.), pp. 105-118.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

[illegible]

Rank	Lake Code	Lake Name	Index No.
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[illegible]

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	[illegible] [illegible] SEC	[illegible] CHLPA	[illegible] [illegible] JUL	[illegible] [illegible] [illegible] P
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE

[illegible] OF LAKES WITH [illegible] VALUES NUMBER OF LAKES WITH [illegible] VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] DISS P	SUS- [illegible] SED	[illegible] CHLOR	[illegible] ORG C	[illegible] SECCHI DEPTH P	[illegible] TOT N
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE

PERCENT OF LAKES WITH HIGHER VALUES THAN/NUMBER OF LAKES WITH HIGHER VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	SECCHI DEPTH SEC	[illegible] CHLOPHA	[illegible] TP	[illegible] TOTAL N	[illegible]
[illegible]	[illegible] LAKE	29 (113)	55 (213)	24 (94)	3 (12)	67 (259)	38 (148)	284
[illegible]	[illegible] LAKE	18 (70)	47 (184)	5 (21)	18 (71)	82 (321)	39 (154)	254
[illegible]	[illegible] [illegible] [illegible]	68 (259)	37 (144)	67 (259)	42 (164)	17 (64)	51 (199)	392
[illegible]	[illegible] LAKE	32 (179)	70 (269)	37 (144)	21 (80)	63 (244)	36 (140)	263
[illegible]	[illegible] LAKE	11 (43)	51 (199)	13 (51)	16 (64)	72 (279)	13 (54)	176
[illegible]	[illegible] LAKE	39 (154)	34 (133)	61 (239)	45 (175)	17 (69)	21 (79)	257
[illegible]	[illegible] LAKE	68 (259)	21 (79)	92 (359)	82 (319)	17 (69)	94 (369)	384
[illegible]	[illegible]	8 (29)	61 (239)	11 (44)	5 (21)	92 (359)	8 (31)	369
[illegible]	[illegible] [illegible] [illegible]	59 (229)	21 (79)	58 (229)	61 (239)	44 (179)	63 (249)	301
[illegible]	[illegible] [illegible] [illegible]	84 (329)	61 (239)	76 (299)	89 (344)	17 (69)	63 (249)	348
[illegible]	[illegible] LAKE	63 (244)	51 (199)	79 (309)	71 (279)	17 (69)	76 (299)	357

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24 15 0807	0.153	24.7		
	24 15 0805	0.162			
	24 15 0815	0.167			
	24 15 0840	0.167			
	24 15 0852	0.170			
[illegible]	10 25 0800	0.110	5.0		
	10 25 0805	0.121			
	10 25 0816	0.115		1.0	
	10 25 0835	0.126			
	10 25 0840	0.190			
[illegible]	11 05 0800		24.7		
	11 05 0810			5.6	
	11 05 0816			1.0	
[illegible]	24 15 0800	0.140	12.0		
	24 15 0805	0.134			
	24 15 0815	0.131			
	24 15 0830	0.130			
	24 15 0845	0.127			
	24 15 0900	0.113			
	24 15 0920	0.109			

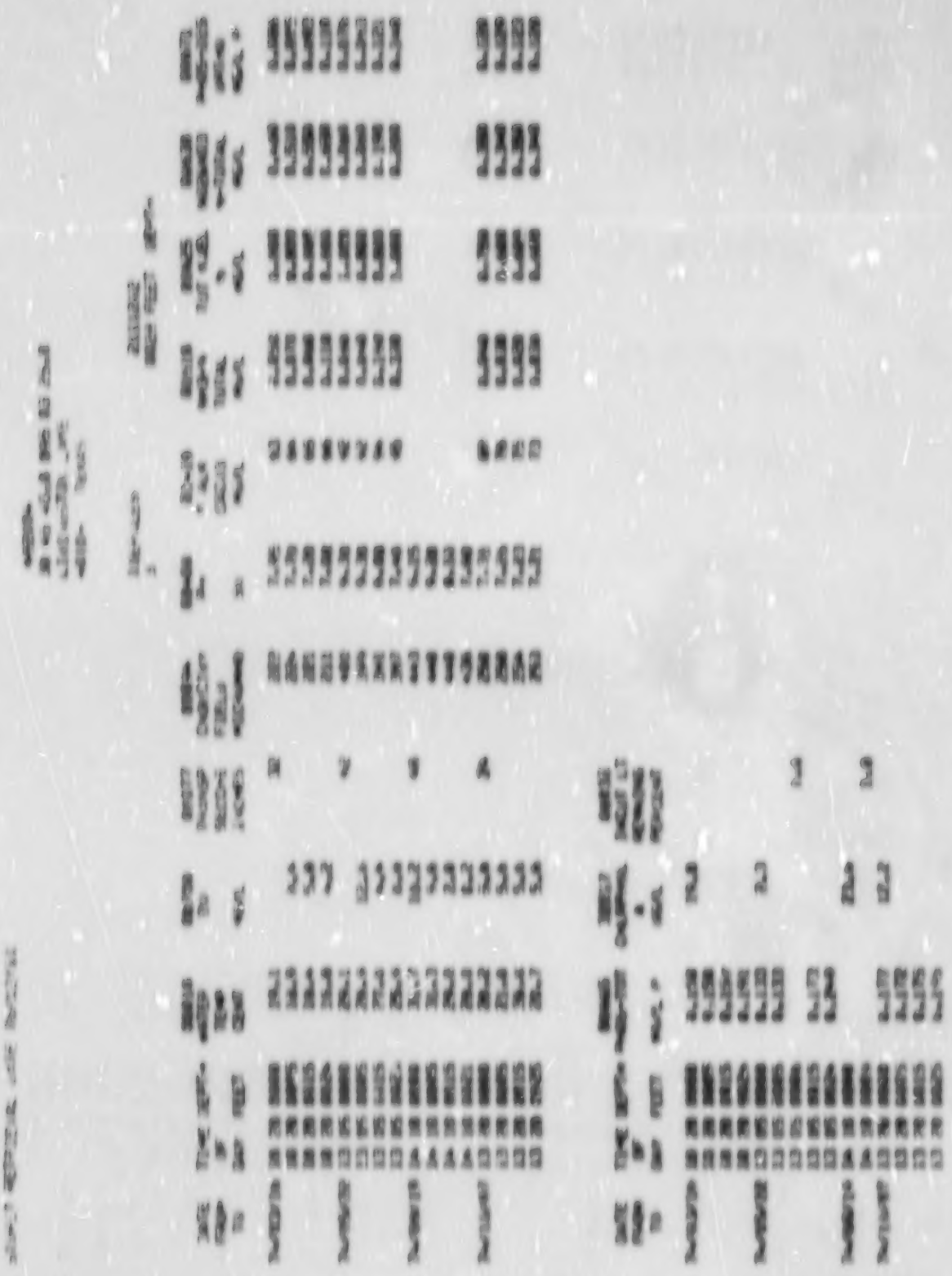
[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24	25	[illegible]	[illegible]	[illegible]
	24	25	[illegible]	[illegible]	
	24	25	[illegible]	[illegible]	
	24	25	[illegible]	[illegible]	
	24	25	[illegible]	[illegible]	
[illegible]	11	18	[illegible]	[illegible]	[illegible]
	11	18	[illegible]	[illegible]	
	11	18	[illegible]		[illegible]
	11	18	[illegible]	[illegible]	
	11	18	[illegible]	[illegible]	
	11	18	[illegible]	[illegible]	
[illegible]	10	38	[illegible]	[illegible]	
	10	38	[illegible]		[illegible]
	10	38	[illegible]		[illegible]
[illegible]	12	18	[illegible]	[illegible]	[illegible]
	12	18	[illegible]	[illegible]	
	12	18	[illegible]	[illegible]	
	12	18	[illegible]	[illegible]	
	12	18	[illegible]	[illegible]	
	12	18	[illegible]	[illegible]	

| | | |



[illegible]

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[illegible]

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APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

[illegible]
38 37 15.0 045 00 45.0 A
[illegible]
[illegible] 3.5 CAMELLIA
[illegible]
100 FT W OF HWY 222 3.5 MI NE OF CAMELLIA
[illegible] 2111254
0005 FEET DEPTH 13465 nd

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	19	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	24	00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	09	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	09	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	09	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

DATE	TIME	DEPTH	00631	00625	00610	00671	00665
			NO3+NO2	TOT KJEL	NH3+	PHOS-DIS	PHOS-TOT
			N-TOTAL	N	TOTAL	ORTHO	
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L P	MG/L P
[illegible]	25	00		2.240	2.780	1.540	
[illegible]	09	30		2.080	0.880	0.430	0.510	0.560
[illegible]	12	30		0.950	0.960	0.435	0.375	0.420
[illegible]	09	30		0.480	1.000	0.850	1.140	0.380
[illegible]	08	45		0.440	1.380	0.184	1.140	0.335
[illegible]	11	45		0.240	1.280	0.044	0.840	0.340
[illegible]	10	40		1.280	0.450	0.430	0.320	0.365
[illegible]	10	00		1.350	0.450	0.435	0.250	0.330
[illegible]	11	15		1.660	1.480	0.310	0.185	0.350
[illegible]	10	30		0.340	1.450	0.430	0.165	0.420
[illegible]	09	15		0.670	1.460	0.430	0.130	0.370
[illegible]	09	30		0.850	0.750	0.410	0.175	0.330
[illegible]	10	20		0.470	0.460	0.430	0.280	0.290
[illegible]	10	40		1.280	0.780	0.815	0.460	0.540

[illegible]

[illegible]

[illegible]

[illegible]							
[illegible]							
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TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.

2.

3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE
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7. AUTHOR(S)
Anonymous (National Eutrophication Survey Staff)

8. PERFORMING ORGANIZATION REPORT NO.
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U.S. Environmental Protection Agency
200 S. W. 35th St.
Corvallis, Oregon 97330

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U.S. Environmental Protection Agency
401 M Street, S. W.
Washington, DC 20460

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Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 07C
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